UNIT 1 - ENERGY

SECTION 2 - YESTERDAY, TODAY & TOMORROW

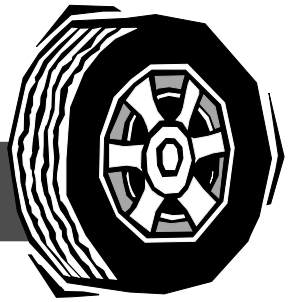
Vocabulary

anthracite	**degrade**	**mains**	**refinery**
barrel	**ethanol**	**natural gas**	**renewable fuel**
bitumen	**fossil fuel**	**natural gas liquid**	**reserves**
bituminous coal	**fuel**	**non-renewable fuel**	**reservoir**
buoyancy	**gasification**	**peat**	**resource**
city gate	**hydrocarbon**	**permeable**	**sediment**
coal	**impermeable**	**petroleum**	**seep**
compressor station	**lignite**	**porous**	**services**
crude oil	**liquefaction**	**recovery measures**	**well**

All around us we see machines doing work. For example, planes, trains, and automobiles carry us along roads, over land and sea, or across town. These machines require **fuels** to function. They burn gasoline, natural gas, jet fuel, diesel, propane, or other fuels in their engines.

Fuels are portable energy sources. By burning them, we can harness their energy to do work. Sometimes we simply burn fuels out in the open, such as wood in a campfire. In industrialized countries like the United States, it is more common to burn fuels in specialized machines such as furnaces.

Many machines we're familiar with don't seem to use fuel, though. Think about washing machines, electric stoves, and air conditioners. These use electrical energy rather than burning a fuel. But where does the electric power come from?



Products from fossil fuels

Human use of fossil fuels is as old as recorded civilization. But until the 19th century, only the oil, coal and gas that naturally seeped from the earth were used, and only in the form in which they emerged.

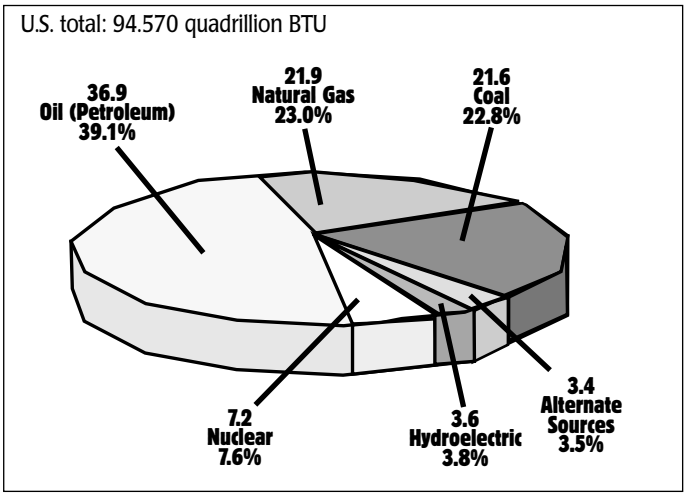
The oil or **bitumen** found in natural seeps was often crude, so its uses were limited. Ancient Egyptians greased their Pharaohs' chariots with bitumen. European sailors coated their wooden ships' hulls with pitch, and Mesopotamians used asphalt as a building material.

Oil lit the lamps of medieval Sicily and served medicinal purposes in both Europe and America. George Washington wrote of a spring on his land, probably a natural gas seep, whose waters "burn freely as spirits."

Broken down into their chemical constituents and recombined in new ways, fossil fuels today are the building blocks of thousands of products. Coal is used to make plastics, perfumes, pesticides, and antiseptics. Oil is used in the manufacture of all of these plus gasoline, kerosene, diesel, paraffin wax, pharmaceuticals, explosives, detergents, cosmetics, adhesives, polishes, paints, fertilizers, and nylon.

Look at page 86 for some comparisons of products that can be made from fossil fuels.

U.S. Consumption of Fuels, 1998



World Consumption of Fuels, 1998

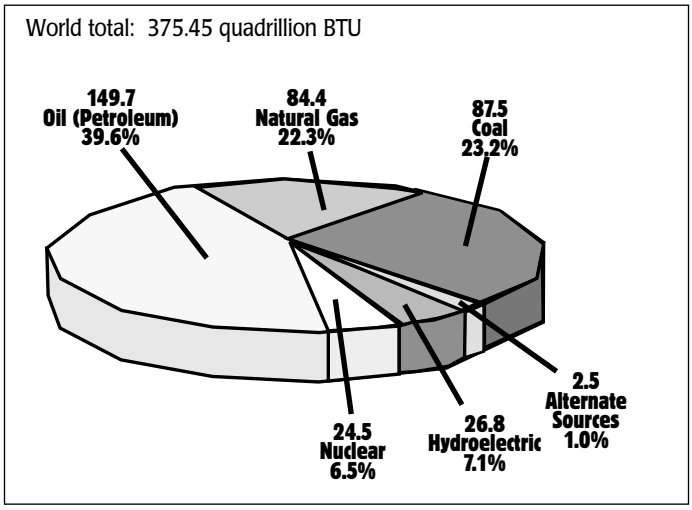


Figure 1-2-1 U.S. and world consumption of fuels (1998)
Source: U.S. Department of Energy

Electricity comes from fuels. Usually a fuel such as coal, oil, or gas is burned at a power plant to boil water for steam. The steam spins turbines to produce electrical energy, which in turn powers the machines in your home.

Let's look at some of the different kinds of fuels available to us.

Fossil fuels

Oil, **natural gas**, and **coal** formed over millions of years, primarily from the remains of dead plants. The remains became buried under sediments and rock. Organic matter from the plant material was incorporated into sediments and buried at increasing depth. Heat and pressure transformed the organic matter into coal, oil, and natural gas that we extract and use today.

Because it takes millions of years to make **fossil fuels**, we call them **non-renewable** fuels. Other fuels are called **renewable** because they are continually renewed at a relatively rapid rate, and therefore do not run out. One example of a renewable fuel is **ethanol**, a transportation alcohol fuel made from crops such as sugar cane and corn.

At the rate we are using them, the earth's **reserves** of oil and gas may be used up in 100 years, and coal in about 230 years. Reserves are the identified deposits that can be recovered economically. In addition, there are undiscovered **resources** in the ground and under the sea. But no one really knows the extent of these undiscovered resources.

Coal

Coal began to form about 300 million years ago. Large regions of the earth were covered with swamps where dense vegetation thrived and ancient seas alternately covered and receded from the land. As the fast-growing plants died and accumulated under the water, they formed a material called **peat**, which is the first step in the formation of coal. Peat is about 5 percent carbon, 90 percent water and 5 percent other substances.

Over thousands of years, thick piles of heavy **sediments** buried the peat, compacting it and changing its composition through added heat and pressure. The result is **lignite**, or brown coal, which is 25-35 percent carbon and about 40 percent water.

Deeper in the earth, continued increased heat changed lignite coal to **bituminous** (soft) **coal**, which is 45-80 percent carbon. More intense heat, usually in rocks compressed during mountain building, created **anthracite** (hard) coal, which is 80-90 percent carbon.

Deposits of peat still exist today. It can be dried and burned, but it produces little heat, much water vapor, and a lot of ash. Lignite, a common fuel in Texas power plants, yields moderate heat and abundant ash. Bituminous coal has a high heat content and is the most common type of coal. Anthracite burns at the hottest temperature with minor ash, but is scarce and expensive. Some coals contain enough sulfur to contribute to air pollution when burned.

The U.S. has about 25 percent of the world's coal reserves. Other areas with large reserves are the former Soviet Union (23 percent) and China (12 percent). Coal reserves are expected to last more than 200 years at current consumption levels. The projected amount of coal resources (unidentified deposits), however, might last much longer.

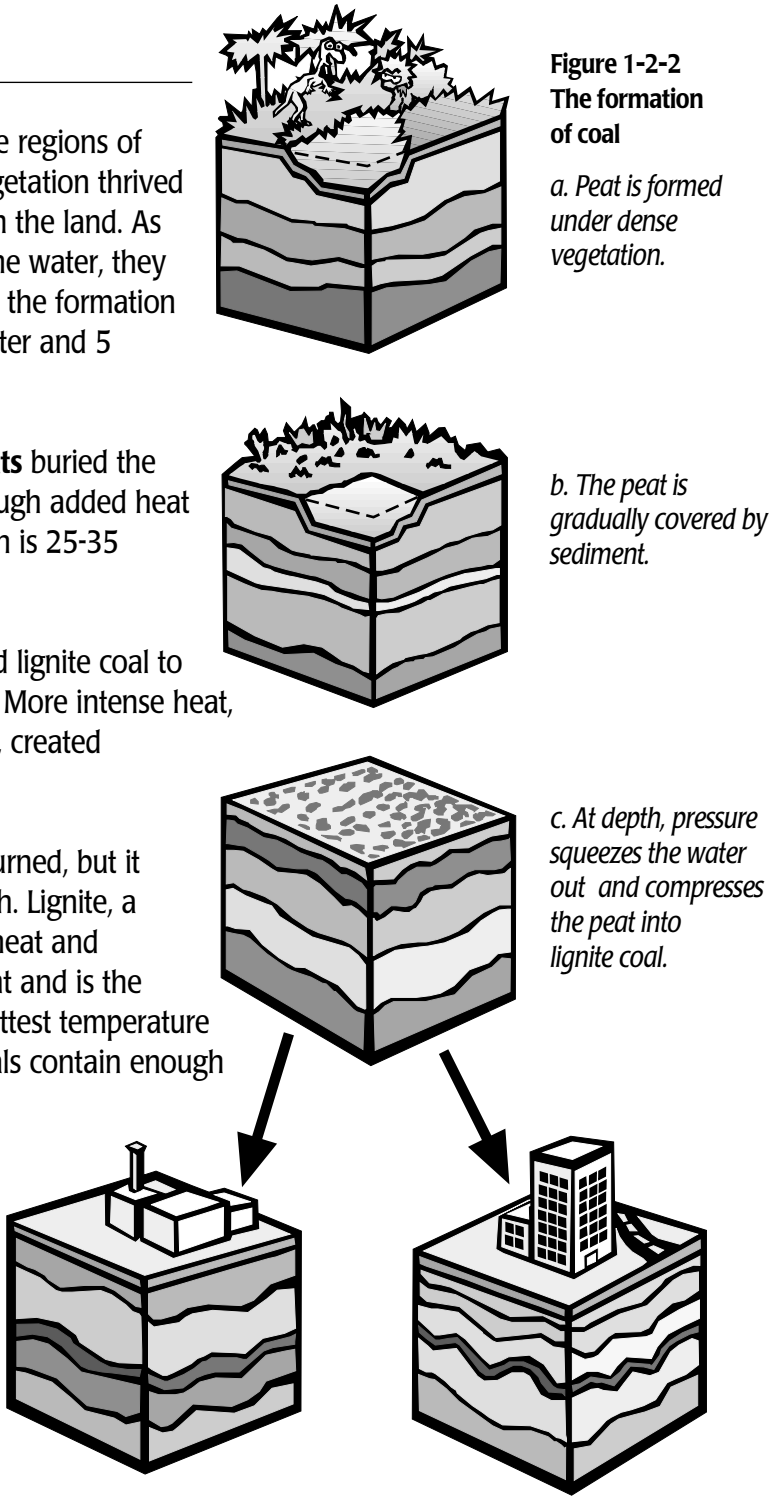


Figure 1-2-2
The formation of coal

a. Peat is formed under dense vegetation.

b. The peat is gradually covered by sediment.

c. At depth, pressure squeezes the water out and compresses the peat into lignite coal.

Coal supplies 24 percent of the world's energy. About 65 percent of all coal used is burned in boilers to produce steam, which drives turbines that produce electricity. More than half the United States' electricity is produced from coal in this manner.

Bituminous coal has a high heat content and is relatively cheap and plentiful, but air-quality problems are associated with its use, and strip mining for coal may result in soil erosion. Reclamation is required to revegetate and recontour mined areas to restore the terrain to nearly its original state.

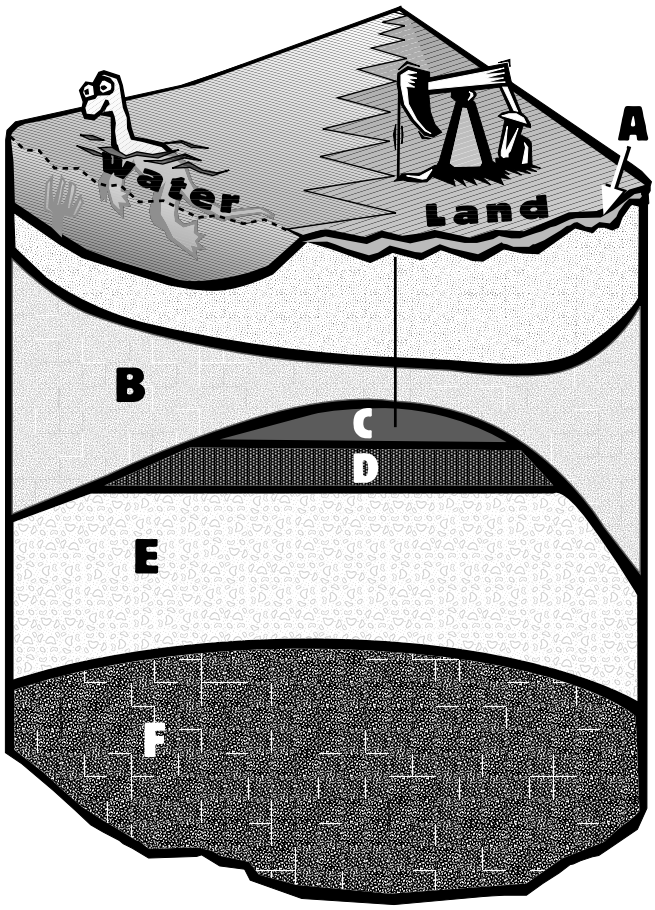


Figure 1-2-3 The origin of oil and natural gas
A. Soil B. Impermeable rock or shale C. Natural gas in sandstone D. Oil in sandstone E. Water in sandstone F. Impermeable rock
*The most useful gas and oil lie trapped within **porous** networks of rocks buried thousands of feet below the earth's surface.*

New technologies can burn coal more efficiently and cleanly. These include coal **gasification** and **liquefaction** methods that have begun to replace old-style coal burners. Even the most efficient coal-burning technologies, however, cause more environmental harm than oil, natural gas, or natural gas liquids such as propane.

Oil

The word petroleum is used today to refer to both oil and gas. It is derived from *petra*, meaning "stone," and *oleum*, meaning "oil"—thus, oil from stone. Crude oil is composed mainly of hydrocarbons, with small amounts of sulfur and other substances. Whereas coal was created from dead vegetation buried close to where it grew, oil and gas formed primarily from transported ancient organic matter buried in fine sediment in deep basins.

Long ago, ancient seas covered the middle of North America from the Gulf of Mexico to the Arctic Circle, as well as many other parts of the earth. The seas teemed with plants and animals, mostly microscopic, whose remains sank and mixed with layers of mud and sand. As ages passed, the remains were buried deeper. Heat and pressure increase with depth. Under these conditions the organic matter was chemically altered into natural gas and oil.

At great depths, mud and sand change to shale and sandstone. Calcium-rich deposits become limestone. Shale rich in organic remains becomes a source rock capable of releasing newly formed gas and oil. **Buoyancy** lifts the lighter gas and oil upward through heavier water and rock. Migration occurs through networks of rock pores.

Gas and oil reserves are created when a geological formation, such as a curved or domed layer of **impermeable** rock, traps hydrocarbons in the rock pores deep underground and allows an accumulation to form. In Texas, the local sandstone and limestone can be porous and permeable. These rocks trap gas or oil under a sealing layer of shale. Petroleum exploration begins with the identification of geologic structures that can trap or store pockets of natural gas and oil.

At fissures in the earth's surface, oil is sometimes found seeping out. Contact with sunlight, bacteria, and oxygen eventually **degrades** the oil into heavier compounds. The world's largest natural seep was discovered by Sir Walter Raleigh in Trinidad. The 104-acre Pitch Lake yields large quantities of asphalt which is exported to countries around the world.

Figure 1-2-4 Titusville, Pennsylvania, the site of the first modern oil well in the United States

The first recorded oil-drilling effort in history was in China in 347 A.D. Using bamboo poles and primitive bits, the explorers drilled down to 800 feet, where a deposit of oil and natural gas was found. The modern oil industry began on August 27, 1859, when Edwin Drake drilled a **well** in Titusville, Pennsylvania, 70 feet deep and struck oil.

When a drill bit first punctures a layer of rock holding oil or gas, it releases pressures that have been sealed within the reservoir for millions of years. These are the force of water pushing against the oil from below, the force of gas pushing down on the oil from above, or the force of gas within the oil seeking to escape.

Later, when the flow has slowed down, water is sometimes injected below the oil pocket, or gas above the oil pocket, to keep production going. These combined primary and secondary **recovery measures** can extract about one-third of a typical deposit. Tertiary or enhanced recovery is expensive and involves pumping steam into the well to heat and thin heavy oil and get it to flow into the well bore.

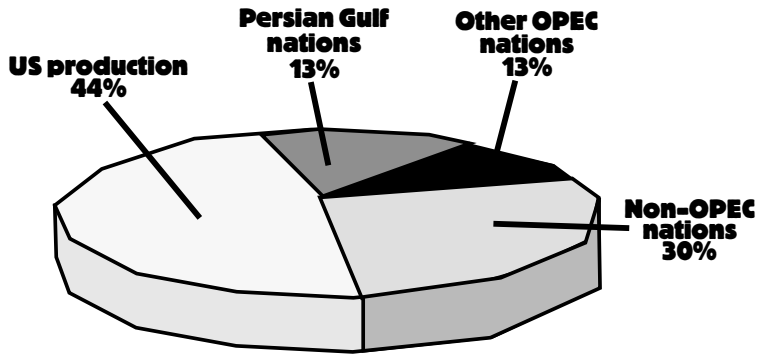


Figure 1-2-5 Sources of U.S. petroleum, 1999
Source: U.S. Department of Energy

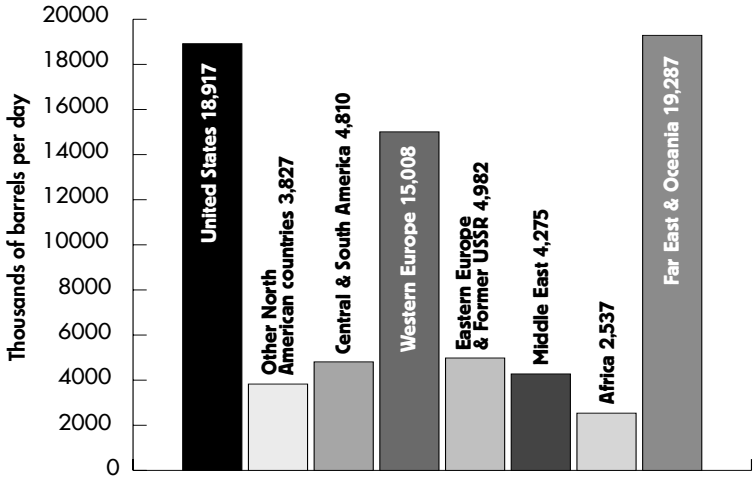


Figure 1-2-6 World petroleum consumption
Source: U.S. Department of Energy

Although the internal combustion engine was invented shortly after the birth of the oil industry, it was many years before car engines became a significant consumer of oil products. Initially, oil was used in medicine, as a lubricant, and to light lamps. Now, with more than 13.5 million motor vehicles in Texas alone (1999) , oil is being consumed at a rapid pace. The United States consumes 19-20 million **barrels** of oil products each day, or 30 percent of the world's daily production.

With increasing U.S. consumption, petroleum imports have increased. Forty-four percent of the oil consumed in the U.S. is produced domestically, while the other 56 percent is imported (figure 1-2-5).

Two-thirds of the world's oil reserves are found in the countries surrounding the Persian Gulf, principally Iran, Iraq, Kuwait, Saudi Arabia and Abu Dhabi. The U.S. has just over 2 percent of the world's proven reserves.

At current levels of consumption, the world's oil reserves are expected to last about 38 years. U.S. government projections estimate there may be another 23 years worth of oil still undetected. However, most of it could not be economically extracted with existing technologies.

Once removed from the well, crude oil is usually sent through a pipeline to a **refinery**, where it is chemically separated into gasoline, jet fuel, diesel, kerosene and other products (figure 1-2-7).

Natural gas

Oil wells themselves are a source of natural gas, for there is some gas in every oil field. Before World War II, the price of natural gas was so low that much of the gas produced with oil ("associated" or "casinghead" gas) was burned in the fields to get rid of it. As recently as 1973 Saudi Arabia flared 18.3 billion cubic feet of gas. This is still done in Nigeria, which does not have the necessary facilities to capture and use the gas. Most U. S. natural gas comes from wells that produce only gas.

Natural gas is believed to have been formed under conditions similar to those that create oil, but the organic matter continued to change into lighter hydrocarbons, chiefly methane. When burned, natural gas has a high heat content and produces fewer pollutants and less carbon dioxide than oil or coal.

Natural gas supplies about 22 percent of the world's energy and about 27 percent of the United States' energy. Most of the world's natural gas reserves are found in the former Soviet Union (34 percent) and the Persian Gulf (29 percent). The United States has about 3.2 percent of the world's gas reserves. Known gas reserves are expected to last about 63 years at current consumption levels. If new technologies are developed that could extract currently known but uneconomic gas deposits, the supply could last roughly 200 years.

At the processing plant, raw natural gas is first sent through a separator. The methane is separated, dried of moisture, cleaned of impurities, and pumped into pipelines for distribution. The valuable heavier hydrocarbons, including propane, are removed, processed, and sent to market for a variety of uses.

As the pipeline-quality gas leaves the processing plant, it enters a **compressor station** where it is pressurized for transmission in pipelines across the country. As a pipeline nears a city, some of the gas is diverted through a **city gate** where its pressure is reduced and it is measured and sold to the local natural gas utility. From the city gate, the utility distributes the gas through a network of smaller underground pipelines called **mains**. Smaller lines called **services** connect with the mains and go directly to the consumer.

Natural gas liquids

Natural gas is composed primarily of methane, but it also contains small amounts of ethane, propane, butanes, pentanes and heavier hydrocarbons, collectively known as **natural gas liquids**. These liquids are separated and stored under pressure in tanks for shipment to factories, where they are used as raw materials to manufacture plastics and other products. Propane is also shipped to terminals that supply it for residential, industrial, vehicular, and other fuel uses.

Yesterday, Today & Tomorrow Resource List

www.public.usit.net/mcnamara/clarion/oil.htm
Clarion County [Pennsylvania] Historical Society
The history of oil production in Clarion County, Pennsylvania, site of the first U.S. oil well.

www.jhu.edu/~virtlab/drill1/drill.htm
Johns Hopkins University
Virtual experiments on drilling for oil, including related costs.

www.census.gov/statab/www
Statistical Abstract of the United States, U.S. Census Bureau
Energy-related national and state statistics, rankings, profiles. Guide to sources of other data from other federal agencies and private organizations.

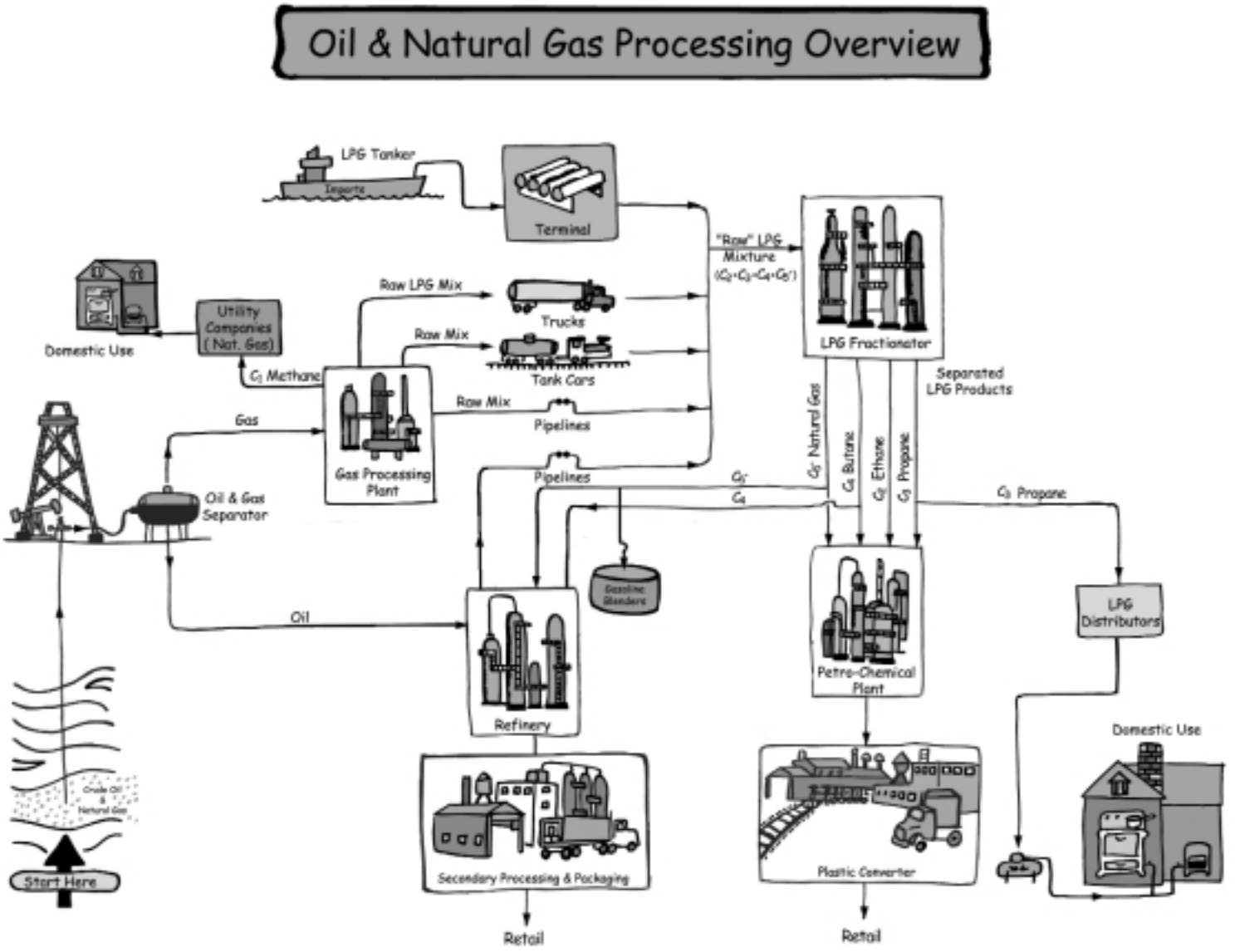


Figure 1-2-7 Oil & Natural Gas Processing Overview

Source: Koch Industries

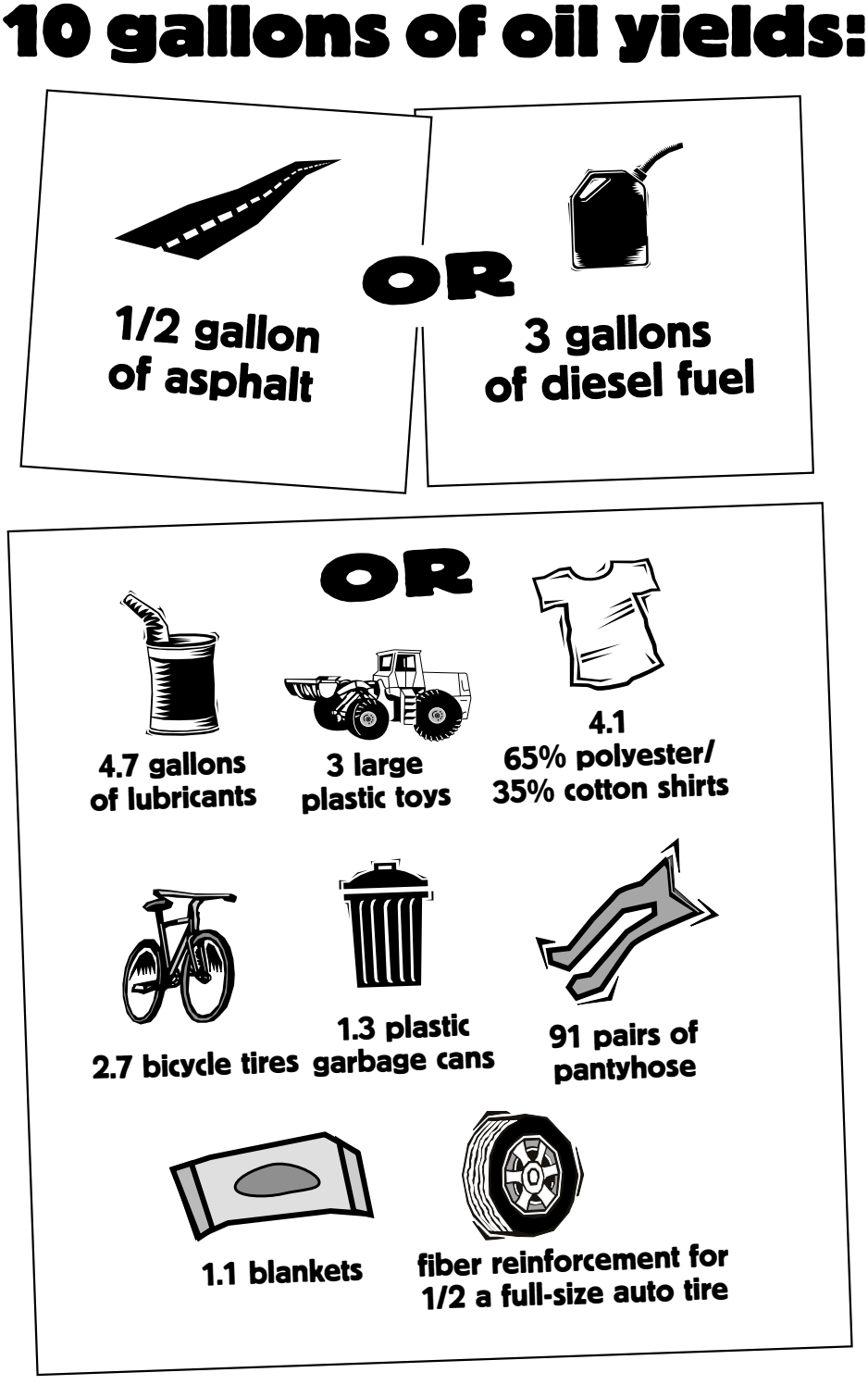


Figure 1-2-8 Some uses of oil

Did You Know?

- **The United States has 4.6% of the world's population, but uses 30% of the world's energy.**
- **Texas produces more oil and natural gas than any other state, and Kentucky produces the most coal.**
- **More than 15.3 million new cars are sold each year.**

Figure 1-2-9 Energy Facts